CLAIMS

1. Fuel cell comprising:
   (a) an anode;
   (b) a cathode;
   (c) a polymer electrolyte membrane placed between the anode and the cathode which comprises at least one polyolefin grafted with side chains containing proton conductive functional groups;
   wherein said fuel cell has:
   - a value of cell resistance at 90°C not higher than 0.30 Ω cm^2;
   - a value of cell resistance at 20°C differing from the value of cell resistance at 90°C of an amount not higher than 90% with respect to the value of cell resistance at 90°C.
2. Fuel cell according to claim 1, wherein the value of cell resistance at 90°C is comprised between 0.02 Ω cm^2 and 0.25 Ω cm^2.
3. Fuel cell according to claims 2, wherein the value of cell resistance at 90°C is comprised between 0.05 Ω cm^2 and 0.20 Ω cm^2.
4. Fuel cell according to any one of claims 1 to 3, wherein the value of cell resistance at 20°C differs from the value of cell resistance at 90°C of an amount not higher than 70% with respect to the value of cell resistance at 90°C.
5. Fuel cell according to claim 4, wherein the value of cell resistance at 20°C differs from the value of cell resistance at 90°C of an amount not higher than 50% with respect to the value of cell resistance at 90°C.
6. Fuel cell according to any one of the preceding claims, wherein the side chains are grafted to the polyolefin through an oxygen bridge.
7. Fuel cell according to any one of the preceding claims, wherein the amount of grafting of the side chains is comprised between 10% and 250%.
8. Fuel cell according to claim 7, wherein the amount of grafting of the side chains is comprised between

40% and 230%.

9. Fuel cell according to any one of the preceding claims, which is a direct methanol fuel cell.
10. Fuel cell according to any one of the preceding claims, which is a hydrogen fuel cell.
11. Fuel cell according to any one of the preceding claims, wherein the polyolefin is selected from: polyethylene, polypropylene, polyvinylchloride, ethylene-propylene copolymers (EPR) or ethylene-propylene-diene terpolymers (EPDM), ethylene vinyl acetate copolymer (EVA), ethylene butylacrylate copolymer (EBA), polyvinylidenedichloride, polyvinylfluoride (PVF), polyvinylidenedifluoride (PVDF), vinylidene fluoride tetrafluoroethylene copolymer (PVDF-TFE), polyvinylidene-hexafluoropropylene copolymer, chlorotrifluoroethylene-ethylene copolymer, chlorotrifluoroethylene-propylene copolymer, polychloroethylene, ethylene-tetrafluoroethylene copolymer (ETFE), propylene-tetrafluoroethylene copolymer, propylene-hexafluoropropylene copolymer, ethylene-hexafluoropropylene copolymer.
12. Fuel cell according to claim 11, wherein the polyolefin is polyethylene.
13. Fuel cell according to claim 12, wherein the polyolefin is low density polyethylene (LDPE).
14. Fuel cell according to any one of the preceding claims, wherein the side chains are selected from any hydrocarbon polymer chain which contains proton conductive functional groups or which may be modified to provide proton conductive functional groups.
15. Fuel cell according to claim 14, wherein the side chains are obtained by graft polymerization of unsaturated hydrocarbon monomers, said hydrocarbon monomers being optionally halogenated.
16. Fuel cell according to claim 15, wherein the unsaturated hydrocarbon monomer are selected from: styrene, chloroalkylstyrene, α-methylstyrene, α,β-

dimethylstyrene, α,β,β-trimethylstyrene, ortho-methylstyrene, p-methylstyrene, meta-methylstyrene, α-fluorostyrene, trifluorostyrene, p-chloromethylstyrene, acrylic acid, methacrylic acid, vinylalkyl sulfonic acid, divinylbenzene, triallylcianurate, vinylpyridine, and copolymers thereof.

17. Fuel cell according to claim 16, wherein the unsaturated hydrocarbons monomers are styrene or α-methylstyrene.

18. Fuel cell according to any one of the preceding claims, wherein the proton conductive functional groups are selected from sulfonic acid groups and phosphoric acid groups.

19. Fuel cell according to claim 18, wherein the proton conductive functional groups are selected from sulfonic acid groups.

20. Polymer electrolyte membrane comprising at least one polyolefin grafted with side chains containing proton conductive functional groups, said side chains being grafted to the polyolefin through an oxygen bridge.

21. Polymer electrolyte membrane according to claim 20, wherein the amount of grafting [Δp (%)] of the side chains is comprised between 10% and 250%.

22. Polymer electrolyte membrane according to claim 21, wherein the amount of grafting [Δp (%)] of the side chains is comprised between 40% and 230%.

23. Polymer electrolyte membrane according to any one of claims 20 to 22, wherein the polyolefin is defined according to any one of claims 11 to 13.

24. Polymer electrolyte membrane according to any one of claims 20 to 23, wherein the side chains are defined according to any one of claims 14 to 19.

25. Process for producing a polymer electrolyte membrane comprising the following steps:

(i) irradiating a polyolefin in the presence of oxygen to obtain an activated polyolefin;

(ii) grafting the obtained activated polyolefin by

reacting the same with at least an unsaturated hydrocarbon monomer, said hydrocarbon monomer optionally containing at least one proton conductive functional group, to obtain side chains grafted on the activated polyolefin;

(iii) optionally providing said grafted side chains with proton conductive functional groups, if the latter are not contained in the unsaturated hydrocarbon monomer;

wherein:

- said irradiating step (i) is carried out at a radiation rate in the range of from 0.10 Gy/s to 100 Gy/s;
- said grafting step (ii) is carried out for a time period in the range of from 20 minutes to 5 hours.

26. Process according to claim 25, wherein the irradiation step (i) is carried out at a radiation rate of from 1.0 Gy/s to 10.0 Gy/s.

27. Process according to claims 25 or 26, wherein the grafting step (ii) is carried out for a time period in the range of from 30 minutes to 4 hours.

28. Process according to any one of claims 25 to 27, wherein the irradiating step (i) is carried out by γ-rays, X-rays, UV light, plasma irradiation or β-particles.

29. Process according to claim 28, wherein the irradiating step (i) is carried out by γ-rays.

30. Process according to any one of claims 25 to 29, wherein the total radiation dose in the irradiating step (i) is in the range of from 0.01 MGy to 0.20 MGy.

31. Process according to claim 30, wherein the total radiation dose in the irradiating step (i) is in the range of from 0.02 MGy to 0.10 MGy.

32. Process according to any one of claims 25 to 31, wherein after the irradiating step (i), the activated polyolefin comprises organic hydroperoxy

in an amount of from 3 x 10^{-3} mol/kg to 70 x 10^{-3} mol/kg.

33. Process according to claim 32, wherein after the irradiating step (i), the activated polyolefin comprises organic hydroperoxy groups in an amount of from 4 x 10^{-3} mol/kg to 50 x 10^{-3} mol/kg.

34. Process according to any one of claims 25 to 33, wherein the polyolefin is crosslinked or non-crosslinked before the irradiating step (i).

35. Process according to claim 34, wherein the polyolefin is non-crosslinked.

36. Process according to any one of claims 25 to 35, wherein the grafting step (ii) is carried out at a temperature of from 15°C to 150°C.

37. Process according to claim 36, wherein the grafting step (ii) is carried out at a temperature of from 45°C to 55°C.

38. Process according to any one of claims 25 to 37, wherein the grafting step (ii) is carried out in the presence of at least one hydroperoxy groups decomposition catalyst.

39. Process according to claim 38, wherein the hydroperoxy groups decomposition catalyst is selected from: ferrous sulfate, ferrous ammonium sulfate, cobalt(II) chloride, chromium(III) chloride, copper chloride.

40. Process according to claim 39, wherein the hydroperoxy groups decomposition catalyst is ferrous sulfate.

41. Process according to any one of claims 38 to 40, wherein the hydroperoxy groups decomposition catalyst is added in an amount of from 0.5 mg/ml to 10 mg/ml.

42. Process according to claim 41, wherein the hydroperoxy groups decomposition catalyst is added in an amount of from 1.0 mg/ml to 6.0 mg/ml.

43. Process according to any one of claims 25 to 42, wherein, in the grafting step (ii), the hydrocarbon unsaturated monomers are dissolved in a solvent.

44. Process according to claim 43, wherein the solvent is selected from: ketones; alchools; aromatic hydrocarbons; cyclic hydrocarbons; ethers; esters.
45. Process according to any one of claims 25 to 44, wherein step (iii) is carried out by using a sulfonating or a phosphorating agent, in inert-gas atmosphere, or in air.
46. Process according to claim 45, wherein the sulfonating agent is selected from: chlorosulfonic acid, fluorosulfonic acid or sulfuric acid.
47. Process according to claim 46, wherein the phosphorating agent is selected from: chlorophosphoric acid or fluorophosphoric acid.
48. Process according to any one of claims 25 to 47, wherein step (iii) is carried out at a temperature of from 50°C to 150°C.
49. Process according to claim 48, wherein step (iii) is carried out at a temperature of from 70°C to 100°C.
50. Apparatus powered by a fuel cell according to any one of claims 1 to 19.
51. Apparatus according to claim 50 which is an engine for vehicle transportation.
52. Apparatus according to claim 50, which is an electronic portable device.